Water Resource Development and Utilization in the Yangtze Valley

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1. Natural condition in the Valley

The Yangtze River, some 6300 km long in total, is the largest river in China and the third in the world(the Nile and the Amazon rank the first and second). The River has a catchment area of 1.8 million km^2, accounting for 18.8% of the nation's total territory. The amount of 960 billion m^3 of runoff annually into the sea, also ranking the third in the world (only inferior to the Amazon and the Congo) equals to nearly five and a half times of the total amount of the Yellow River, the Huai River and the Hai River.

1.1 Geomorphology

With its origin from the Qinghai-Tibet Plateau, the Yangtze runs through such provinces/municipalities/autonomous regions as Qinghai, Tibet, Sichuan, Yunnan, Chongqing, Hubei, Hunan, Jiangxi, Anhui, Jiangsu and Shanghai, with its tributaries extending to Gansu, Shaanxi, Guizhou, Henan, Zhejiang, Guangxi, Fujian, and Guangdong provinces/autonomous regions. The Yangtze Valley covers an area ranging from Mangkang Mountains and Ningjing Mountains in the west which is the divide with the Nanchangjiang River system to the East China Sea in the east, from Bayankala Mountains, Qinling Mountains and Dabie Mountains in the north connecting with the Yellow River and Huai River systems to the Nanling mountains, Wuyi mountains and Tianmu mountains in vicinity with the Pearl River system and the Fujian and Zhejiang river systems in the south.

The Yangtze Valley is various in topography, consisting of plateaus, mountainous regions, hilly lands, basins and plains. In the Valley, 84.7% are plateaus, mountainous regions, hilly lands and basins, 11.3% are plains, and 4% are rivers and lakes. High in the west and low in the east, the Yangtze has formed a huge basin of three cascades. The first cascade is composed of the southern part of Qinghai province, the Xipu plateau in Sichuan and the mountainous valley regions of the Hengduan Mountains, generally 3500-5000 m in elevation. The second cascade consists of the Qinba mountainous area, Sichuan basin, and mountainous regions in Hubei and Guizhou, generally 500-2000 m in elevation. The third, below 500 m in elevation, covers the Huaiyang mountainous area, the hilly area in the south of the Yangtze, and the Yangtze Middle and Lower Reach plain areas.

The Yangtze, from its origin to the estuary, has a fall of over 5400 m. The section above Yichang is called the Upper Reach, 4500 km long, accounting for 70.4% of the Yangtze's total, with a controlled catchment area of 1 million km^2, of which, the part above Yibin is called Jinshajiang(including Tongtian river and Tuotuo river), 3464 km long with a fall of 5100 m, accounting for 95% of Yangtze's total fall. Out of the three gorges, the Yangtze enters its Middle and Lower Reach plain area. From Yichang to Hukou is the Middle Reach, 955 km long with a catchment area of 680,000 km^2. The remaining part from Hukou to the estuary is called the Lower Reach, 938 km long with an interval catchment area of 120,000 km^2.

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The Yangtze Valley is highly developed in water systems with a large number of tributaries. There are 49 tributaries, each having a catchment area over 10,000 km^2. The Yalong, Minjiang, Jialing and Hanjiang are rivers with catchment area over 100,000 km^2. The Jialing is the largest in catchment, say, 160,000 km^2, the Minjiang is the No.1 in runoff, say, 90 billion m^3, while the Hanjiang is the longest, say, 1577 km. The major tributaries of the Yangtze are distributed as follows: Cishui and Wujiang in the south and Yalong, Minjiang, Tuojiang and Jialing in the south in the Upper Reach; in the Middle Reach, Qingjiang, four rivers of Dongting Lake system(Xiangjiang, Zishui, Yuanjiang, and Lishui), four rivers of Poyang Lake system(Ganjiang, Fuhe, Xinjiang, and Raohe), and Xiushui in the south and Hanjiang in the north; while in the Lower Reach, Qinyi and Shuiyang system and Tai Lake system in the south and Cao Lake system in the north. Most part of water from Huai River also enters into the Yangtze through the water channel.

1.2 Hydrological characteristics

The Yangtze Valley belongs to subtropical monsoon climate, temperate and humid. It is abundant in rainfall, averaging 1,100 mm annually. The rainfall, unevenly distributed, decreases gradually from southeast to northwest. The precipitation from May to October takes approximately 70-90% of the yearly total.

Yichang, the control station in the Upper Reach of Yangtze, has a catchment area of about one million km^2. The average annual runoff is 451 billion m^3. The maximum peak flow investigated is 105,000 m^3/s in 1896 and the measured minimum flow is 2,770 m^3/s in 1979. While Datong, the control station in the Lower Reach, has a catchment area of 1.7 million km^2 with an average annual runoff of 915 billion m^3. The measured maximum peak flow is 92,600 m^3/s in 1954 and the minimum flow is 4,620 m^3/s in 1979.

Floods in the Yangtze Valley are basically formed by storms, concentrating on the period from May to October. The rainy season occurs earlier in the middle and lower reaches than in the upper reach; first in the south of the Yangtze, then in the north. The earliest is in the Dongting and Poyang lake systems, say, in April-July. According to statistics, there were 8 years with the maximum flood peak flow over 80,000 m^3/s and 23 years with the max. peak flow exceeding 70,000 m^3/s at Yichang since 1153. Since 1860, more than 20 fairly large floods took place in the middle reach.

The sediment at hydrological stations along the Yangtze has 85-98% concentrating on the wet season, therefore, the amount of rainfall and its distribution in time and space in the wet season directly impacts the sediment amount. According to statistics, the suspended load at Yichang averages 530 million tons annually with a sediment concentration of 1.18 kg/m^3. While the figures at Datong are 472 million tons and 0.52 kg/m^3 respectively.

1.3 Infrastructure

●❄ Communications and transportation

The Yangtze Valley is one of the regions highly developed in communications and transportation in China. An integrated communication and transportation system including waterway, railway, highway and aviation has been set up. The Yangtze, the most developed river in navigation in China, has been regarded as the Golden Waterway. Totally 3,600 rivers, large and small, are navigable in the Valley with a mileage of 77,500 km, accounting for 70% of the river navigation in China. Among them, 2,540 km is navigable for vessels over 1,000 tonnage and 4,226 km for those over 300 tonnage. Along the trunk stream of the Yangtze, there are 216 harbors/ports, large and small, of which, 48 are major ones, each has a yearly throughput over 200,000 tons. Nanjing, Wuhan, Zhenjiang, Nantong, Wuhu, Anqing, Ma'anshan, Jiujiang, and Chongqing are important harbors. After completion of the Three Gorges Project, which will canalize the 660 km channel between Chongqing and Yichang, a fleet of 10,000 tonnage could sail directly upstream to Chongqing in half of a year. At present, the river channels in the middle

and lower reaches have been improved by lots of bank protection and dredging works and shallow channels have been maintained to be 2.9m navigable depth at minimum by mechanical and blasting dredging.

There exist 20 plus railway arteries in the Valley with a mileage of 22,700 km, mainly: Chengdu-Kunming, Beijing-Kowloon, Beijing-Guangzhou, Zhicheng-Liuzhou, etc., from south to north, and Xiangfan-Chongqing, Changsha-Guiyang, etc., from east to west.

The Valley is densely connected by highways with a mileage of 600,000 km, of which more than 40,000 km are highways above grade II.

●❄ Flood control works

About 3,600 km dykes along the Yangtze have been repaired, heightened and strengthened, greatly improving the flood control capability. The river channel regulation and cutoff works in the lower Jingjiang Stretch have enlarged the discharging capacity of the channels. A fairly complete embankment protection system against flood has been formed. The flood diversion and detention basins constructed for flood control in the Yangtze Valley provide an effective storage capacity of over 50 billion m^3. Meanwhile the completed reservoirs, say, 119, play a very important role in the flood regulation and mitigation of flood threatening to the regions downstream of the reservoirs. The progressing Three Gorges Project, as required by the overall flood control construction in the Yangtze Valley, is gradually forming a flood control system in the middle and lower reaches centering on the Three Gorges Project.

The integrated harnessing/rehabilitation in the plain and lake areas in the middle and lower reaches has been conducted by taking measures of joining detention basins, dredging river networks, and improving draining outlets. 4 million ha of waterlogging area had been rehabilitated till 1995, accounting for 85.7% of waterlogging vulnerable areas in the Valley. Of them, 3 million ha reached the waterlogging control standard over one in five year storm.

●❄ Agriculture irrigation

Up to 1995, some 45,600 reservoirs of various scales had been constructed in the Valley with a total reservoir capacity of 142 billion m^3. In the 14.6 million ha of effective irrigation area which accounts for 60% of the total farmland area of the Valley, there are 5.8 million km^2 irrigated by reservoir and 6 million ha by water diversion and pumping.

●❄ Hydropower generation

The constructed and progressing hydropower projects till 1995, most of which are comprehensive utilization projects, had a total installed capacity of 42,700 MW with a yearly yield of electricity of 191 billion kW.h. The large scale projects are: Three Gorges Project(18,200 MW, installed capacity) and Gezhouba(2,715 MW) on the Yangtze, Ertan(3,300 MW) on Yalong River, Gongzui(700 MW) and Tongchengzi(600 MW) on Dadu River, a branch of Mingjiang River, Baojushi(640 MW) on Bailong River, a branch of Jialing River, Wujiandu(630 MW) and Dongfeng(510 MW) on Wujiang River, Dongjiang(500 MW) on Xiangjiang River, Wuxiangxi(1,200 MW) on Yuanshui River, Danjiangkou(900 MW) and Ankang(800 MW) on Hanjiang River, Geheyan(1,200 MW) on Qingjiang River, Wan'an(500 MW) on Ganjiang River, etc..

1.4 Ecological conditions

●❄ Soil

The Valley consists of soils of various types, which are characterized by horizontal and vertical zonal distribution. In the south of the Yangtze are widely distributed red loam and loess which are typical soil in subtropical zone; while in the north distributed yellow-brown soil, brown

soil and yellowish-brown soil. In the west of the Valley developed mountain and plateau soil, mainly mountain meadow soil, sub-alpine meadow soil, alpine meadow soil, alpine plain soil and alpine glacier soil. There also exist some non-zonal soils, namely, bog soil, paddy soil, meadow soil, tidal soil, alluvial soil, purple soil and limestone soil. The mountain soils are distinctly vertically distributed.

●❄ Vegetation

With the exception of source area in the high elevation and cold climate which belongs to desert vegetation, the Valley lies in two kinds of vegetation zones, i.e., medium subtropical and north subtropical, containing more than 14,600 species of vegetation, characterized by subtropical broadleaf evergreen and concurrently with south tropical and north temperate vegetation. The natural vegetation is mainly distributed in the mountainous and hilly areas, while in the plain areas, the artificial vegetation prevails. It is distinct in distribution vertically and horizontally. The forest area is about 300,000 km^2 in the Valley with a coverage of 22%. The timber potential is about 2.58 billion m^3, mainly concentrating on the upper reaches of the Yangtze and its major tributaries. Forest is also dotted in the middle and lower reaches of the Yangtze.

●❄ Fauna

Lots of kinds of animals avail in the Valley, including some state protected animals. Some famous mammals are Yunnan golden monkey, panda, leopard, Chinese dolphin, white-lip deer, etc., birds are white crane, Chinese merganser, red-crowned crane, red-chest pheasant, etc., reptile such as Chinese alligator, and fish as Chinese paddlefish, Chinese sturgeon, Chinese sucker, etc..

●❄ Soil erosion

Soil erosion is one of the major eco-environment problems in the Valley. The Yangtze upper region, abundant in forest resources, is the second largest forest zone in China, only inferior to Northeast China, and also the important natural shield for water and soil resources prevention of the Yangtze. However, irrational development for years results in severe soil erosion. Forest vegetation has been sharply decreased and the soil erosion area and intensity gradually increased. The soil erosion area reaches up to 355,000 km^2 in the upper reach of the Yangtze with a yearly erosion up to 1.4 billion t, accounting for 63% of the total erosion area in the Valley. The damage to forest causes soil erosion and greatly decreases the self-regulation capability of ecosystem, as a consequence, soil degradation area increases and such disasters as mudflow, landslide and mount collapse occur frequently and gravely.

●❄ Water pollution

With the development of industrial and agricultural production, untreated industrial wastewater, slag and field water which contains residue of pesticide have been discharged into rivers in a large amount, causing severe pollution to the water quality in the Yangtze. Owing to the large amount of flow in the Yangtze and the strong self-purifying capability of the River, the water quality in the water body, overall speaking, is still good. But the water close to the banks of cities has been polluted. The pollution in some tributaries is very serious. Almost all riparian cities are confronting with the challenge of water pollution. Water shortage in quality occurs in the rural river network areas.

2. Culture of the Valley

2.1 Historical overview of the Yangtze

The Yangtze River is the “Mother River” of the Chinese Nation. The findings of various fossils of ancient anthropoids, including *Lama, Kaiyuan, Yuanmou* in Lufeng, Yunan Province, and those in Jianshi and Badong, Hubei Province, demonstrate that, some 8 million years ago, there has been the footprints of the ancestors of human beings in the Yangtze River Basin. The

Yuanmou, lived in the early of Paleolithic Age about 1.7 million years ago, is the earliest anthropoid fossils found in China so far. The civilization of Neolithic Age in the Yangtze River Basin also has a history of about 6,000~7,000 years, which is as old as the well-known Yangshao and Lonshan Civilization in North China.

In Neolithic Age, man was capable of making simple tools, conducted fishery and agricultural production. They learned pottery-making, bamboo-braiding, silk and flax-weaving. The arts, sciences and religions also germinated at that time. The relics dispersed in the Basin provide evidences for the ancient civilization, mainly including the Daxi Civilization in the upper reach, Qujialing Civilization in the middle reach, and Hemudu, Majiabang, Liangzhu and Qinglian Civilization in the lower reach. All these relics can be traced back to some 4,000~7,000 years ago.

In Shang and Zhou Dynasty(about BC 1,600~BC 771), the Bronze civilization and metallurgical technologies were considerably developed, and there are abundant relics now scattered among the Basin. In Spring-Autumn and Warring Period, China already had sketchy geographical and administrative divisions. In the upper reach of the Yangtze, there were some small subordinated states like Ba and Shu. In the middle and lower reaches, there were Chu, Wu and Yue State. All these feuds or states brought into being the far-reaching civilizations such as Bu-Shu, Chu and Wu-Yue, among which the Chu Civilization, with widespread influences and long history, is considered as the representative one in the Yangtze River Basin.

In Qin and Han Dynasty, along with the unification of the country, the civilizations of Chu, Ba-Shu and Wu-Yue began their mergence with the Central Plains Civilization(in the Yellow River Basin of North China).

2.2 Traditional uses of the Yangtze

The harnessing and utilization of the Yangtze began in the Spring-Autumn and Warring Period. Many water conservancy projects for irrigation, flood control and transportation were built through ages of efforts. Dujiangyan Weir, Lingqu Canal, Jingjiang Great Dikes and the Grand Canal are some of the most famous among them.

- Irrigation Projects

Dujiangyan Weir is located on mainstream of the Minjiang River in Sichuan Province and is one of the most famous irrigation projects in China. Its construction began in Qin Dynasty when Emperor Zhao was on the throne(BC 256~BC 251). The project mainly consists of three parts, namely, Yuzui(fish mouth), Feishayan(sand-flying weir) and Baopingkou(bottle mouth). Yuzui diverts the water from the river into a channel; Feishayan is a desanding structure through overflow. Baopingkou is an intake, and it also play a part in flood control. So far, the irrigation areas of the project reach some 600,000 ha, and it has other benefits such as power generation and flood regulation, etc..

The construction of water conservancy projects in Dianchi Lake area of Yunan Province can be traced back to the West Han Dynasty. During Yuan Dynasty, Songhuaba Dam Project, the largest in scale, was built on a gorge mouth of the Panlongjiang River. It diverts the river water into the lake for irrigation, flood regulation and storage purposes. After ages of maintenance and expansion, besides the above functions, it can also supply water and power for Kuming city, the capital of Yunan Province.

In ancient times, the Hanjiang River Basin had three major irrigation areas, namely, Hanzhong, Nanyang and Manhe, which were started in Han Dynasty, West Han period and Qin Dynasty respectively.

- Projects for Flood Control

The well-known Jingjiang Great Dike is a product of ages of construction beginning from

Spring-Autumn and Warring Period. Its history can be divided into four periods: commenced in Spring-Autumn and Warring Period and Jin Dynasty, completed various sections in Song Dynasty, came into being as a whole in Ming Dynasty, and heightened and reinforced in modern times. It is said that the dikes along the Hanjiang River, a tributary of the Yangtze, was started in Han Dynasty, and that of the Ganjiang and Fuhe River was started in Ming and Qing Dynasty.

Long ago, the enclosed embankments began to be used in lakeside areas to protect the farming lands from being flooded. Most of these embankments in the north of Dongting Lake area were constructed in Ming Dynasty and that in the south were constructed in Ming and Qing periods.

Sea dikes can resist the erosion of tides, protect the banks from collapse or failure and secure the safety of towns and lands. The Jiangsu-Zhejiang Sea Dikes, located at the mouth of the Yangtze, is about 400 km long. Its construction began at the mouth of Qiantangjiang River in East Han Dynasty, and the later expansion in East Jin Dynasty built the dikes to present Baoshan area. The whole dikes are finally formed in Tang and Song Dynasty. The largest numbers of sea dikes were built in Ming and Qing Dynasty, and the engineering techniques are developed considerably.

▪ Canals

The earliest development of canals was carried out in the middle and lower reaches of the Yangtze River. In the Spring-Autumn and Warring Period, continuous fights and wars among the states of Wu, Yue and Chu made the canal a necessity to facilitate the transportation of soldiers and provisions.

Lingqu Canal in Qin Dynasty and the Grand Canal in Sui Dynasty are two of the most famous ancient canals in China. Both of them played very important roles in ancient times and the Grand Canal is still in use now. However, some of the ancient canals have fallen into disuse due to silt deposition and lack of repairs.

3. Development and utilization planning of the Valley

3.1 Principle of planning

The river harnessing and water resource development and utilization planning for the trunk and branches of the Yangtze shall be conducted in compliance with state's relevant laws, in conformity with national construction guidelines and policies, and firmly following the basic principle of *"integrated planning, overall development, appropriate division of responsibilities, and implementation by stage"*. Such relations should be properly dealt with as long term and short term, trunk and branches, upper and lower reaches, large and small scales, flood control, power generation, irrigation and navigation, hydro-power and thermo-power, power generation and supply, overall and local benefits, water and soil conservation and water resource protection and utilization, etc.. At the same time it shall be based on the construction strategy of national economy, proceeding from the actual situation of the Valley, and considering the requirements of related departments of national economy in an overall way.

3.2 Flood control planning

● Formation of floods

Floods in the Yangtze Valley are basically formed by storms, concentrating on the period from May to October. The rainy season occurs earlier in the middle and lower reaches than in the upper reach; first in the south of the Yangtze, then in the north. In the common year, the flood peaks in the Yangtze and its tributaries stagger to each other, so the middle and lower channel of the Yangtze can discharge one by one the floods from the tributaries in the middle and lower reaches and that from the mainstream and tributaries of the upper Yangtze without any big flood disasters. However, in case of abnormal meteorology, big floods would occur, resulting in flood

disasters which are widely distributed in the valley. The most serious flood disaster vulnerable region is the Yangtze middle and lower reach plain area where the discharge capacity of river channels and the inflow of flood is in big difference. The big floods in the middle and lower reach plain area are formed in two types: type 1 is caused by extremely large storms occurring in specific stretches of the mainstream or several tributaries which is characterized by large flow and high peak, for instance the floods in 1860, 1870, and 1935; type 2 is formed by all-basin storms, that is, the floods from the mainstream and the tributaries encounter each other, as a consequence, causing lasting floods with large flow and high peak, such as floods in 1954, 1931 and 1998.

●❄ Flood control standard

Considering the importance of the Yangtze middle and lower reaches in the national economy and possible impact to be caused by flood disasters and taking the flood control standards for big rivers both at home and abroad as reference and proceeding from the actual situation of flood control in the Yangtze, the flood control standard for the Jingjiang Stretch of the Yangtze should at least stand one in 100 year flood and favorable conditions should be created for this stretch to discharge safely in case of flood similar to 1870 without any dyke breaching on both banks so as to avoid devastating flooding. The standard for the section below Chenglingji takes the actual flood in 1954 as its defending standard which, as condition is favorable, will be raised at Wuhan, Nanjing and Shanghai.

●❄ Short term flood control planning

The embankments along the Yangtze will be heightened and strengthened as required for the design water levels above the sea level in the following: Shashi 45.00m, Chenglingji 34.40m, Hankou 29.73, Hukou 22.50m, Datong 17.10m, Nanjing 10.60m(11.10m when effected by typhoon), Jiangyin 7.25m(8.04m when effected by typhoon).

Safety construction of flood diversion and detention basins should be rationally conducted based on the overall planning for flood control in the middle and lower reaches of the Yangtze. As calculated for major embankments based on the above criteria, in case of 1954 flood, some 50 billion m^3 of flood needs to be diverted and detained under the condition of ideal operation of diversion region, of which, 5.4 billion m^3 in Jingjiang area, 32 billion m^3 in Chenglingji area(16 billion m^3 in Dongting Lake area and Honghu Lake area respectively), 6.8 billion m^3 in Wuhan area and 5 billion m^3 in Hukou area (2.5 billion m^3 in Poyang Lake area and Huayang River area respectively). The construction of safety islands and safety buildings(for emergency), evacuation roads and flood diversion facilities in the diversion and retention region should be conducted in a planning way.

As to those regions which are not key ones and will hinder flood discharge and which will be unfavorable to the river regime control, such measures will be taken as “evening the basins for flood discharge and returning farming to water storage” so as to guarantee the safety of people’s lives and properties on one hand and enlarge the flood storage and discharge capacity of rivers and lakes on the other hand.

Based on the regulation lines of “giving consideration to both storage and discharge and taking discharge as the main” and “storage in the upper and dredging in the lower, and tackling problems both on the surface and at the root” and considering the needs of national economic development, it is imperative to construct some comprehensive utilization reservoirs both in the mainstream and the tributaries of the Yangtze to uninterruptedly increase the flood control capacity in the middle and lower reaches.

●❄ Waterlogging control planning

There is about 4.6 million ha of waterlogging vulnerable farmland in the Yangtze Valley, of which 93% is in the middle and lower reach plain area where located some important cities such as Wuhan, Suzhou, Wuxi, Shanghai. Therefore, it is the key region for waterlogging control

planning.

The basic task of waterlogging control in the Valley is to further improve the waterlogging drainage capacity. On the short term basis, it is to make most of this region reach or exceed the standard of one in ten year storms. The overall planning should be conducted based on the natural, economic and social conditions. The waterlogging control standard will be determined according to the nature of different waterlogging zones, taking the measure of combination of self-draining and draining by pumping and arranging appropriately inland lakes for waterlogging storage. Meanwhile, flood control, waterlogging drainage and irrigation should be considered in an integrated way.

3.3 Irrigation planning

●❄ Situation of irrigation

In 1997, there are 23 million ha of cultivated land in the Valley with a population of 415 million. The total water consumption is 173.5 billion m^3, of which, 106 for agricultural usage, accounting for 61% of the total, which decreases by 5% in comparison with the 66 percentage.

●❄ Irrigation planning

To develop the construction of water conservancy works and ensure the stable increase of agricultural production is an important work to be conducted for the integrated harnessing and development in the Valley. As preliminarily analyzed, it is predicted that the effective irrigation area will be increased to 17 million ha in the year 2010 and the irrigated rate will be up to 74%. Considering the application of water saving measures in the agricultural irrigation would possibly decrease the irrigation quota in the farmland, the water demand for agricultural irrigation is determined to be 163 billion m^3 at the irrigation guarantee P=75%.

Based on the planning requirements, what should be done is: firstly, to give full play to existing water conservancy works by enhancing the follow-up construction and counterpart works and also by tapping the latent power, and, as it is appropriate, to construct new works. Secondly, to strengthen the scientific research and business management to raise the agricultural economic benefit and increase the grain yield of unit area. Thirdly, to enlarge the irrigated area and increase the grain production. The key points to be developed are the hinterland of Sichuan, the Nanyang Basin, the Jietai Basin in Jiangxi, the Central Plateau in Yunnan, the Hengshao hilly area in the south of Hunan, the Poyang Lake area, and the Dongting Lake area where exist large-area water shortage and have huge potential of production and also are major bases of commercial grain and economic crop production.

3.4 Urban industrial and domestic water use planning

●❄ Present status of urban industrial and domestic water use

Thanks to the affluent water resource in the Yangtze Valley, the water supply sources for the cities alongside both the mainstream and tributaries can be secured. In recent years, the structure of water use has been changing with the outcome that the proportion that urban industrial and domestic water use covers of the total water assumption rises constantly. In 1997, the water used for urban industrial and domestic consumption was 58 billion m^3, covering 33% of the total water use compared with the figure of 29% of the year 1993. Of the 58 billion m^3 of water, 48.8 billion m^3 of water goes to industrial sector accounting for 28% of the total water use.

●❄ Prognosis of urban industrial and domestic water use

According to preliminary analysis, by the year 2010 the industrial water consumption will have increased with the accretion of industrial production and the water demand will see a great leap. On the other hand, with the urbanization and constant improvement of people's housing

conditions, the water demand for urban domestic use will also increase with the time. It is predicted that by the year 2010 the water demand for urban industrial and domestic use will have amounted to 105 billion m^3 with the percentage out of the total rising to 35%, of which 85 billion m^3 of water are for industrial use covering 28% of the total. The domestic water demand will have risen to cover 7% of the total demand.

●❄ Some suggestions on urban industrial and domestic water use planning

The guidelines of " tapping new resources while reducing consumption" must be followed in order to solve the problem of urban water supply, and other suggestions include:

(1)❄speeding up the construction of water sources and water supply facilities;

(2)❄strengthening the management of water supply projects;

(3)❄calling for water saving and scientific using; and protecting water sources ;

(4)❄improving the economic benefit of water supply;

(5)❄meeting the water quality and quantity requirements of industry, communication, energy, recreation and domestic uses in a comprehensive way;

(6)❄advocating water recycling and re-use;

(7)❄restructuring the industries to raise the proportion of recycled water use in industry and reduce sewage discharges;

(8)❄incorporating urban water supply in the urban overall development planning.

3.5 Development of tourism and recreation

The Yangtze Valley has colorful landscapes and places of historical interests, such as the picturesque world-known Three Gorges and the small three gorges on Daninghe river as well as distinctive mountains- Mt. Huangshan, Mt. Lushan, Mt. Wudang and so on. The beauty of West Lake in Hangzhou ranks first in the world, the gardens of Suzhou enjoy great popularity, and such ancient buildings as Tengwang Chamber, Yellow Crane Tower and Yueyang Tower have global reputation. The Yangtze Valley is one of the origination places of the Chinese people, and there have been numerous historical relics left from every dynasty. The water resource projects themselves have evolved into new heat points for tourism, such as Dujiangyan Weir, Jiangdu Water Conservancy Project, Gezhouba Project and Three Gorges Project as well. In the course of implementing the Yangtze development planning, care must be taken to protect the places of historical interests and prevent from water pollution, so as to facilitate tourism and recreation.

3.6 Navigation planning

The Yangtze is the most developed inland river in China with respect to navigation, with the mainstream connecting Southwest, Central and East China. The major navigable tributaries include Minjiang River, Jialingjiang River, Wujiang River, Hanjiang River, Dongting Lake system, Poyang Lake system, Caohu Lake system and Taihu Lake system. The Yangtze system is connected to Huaihe River system by the Grand Canal, constituting the most important inland navigation system of China. The Yangtze River navigation plays an important role in the economic development and communication network in the Valley.

The targets under planning are:

- ❄preliminarily realizing the modernization of navigation channel, ports, ships,

telecommunication and navigation guide through the near term construction and technological innovation, gradually evolving into a unimpeded navigation system with the trunk and tributaries connected, giving full play to the waterway transportation on the Yangtze;

- ❄ with the construction of Three Gorges Project, improving essentially the navigation conditions of the upstream river reaches (the Yangtze within Sichuan territory);

- ❄ stabilizing navigation channel and riparian alignment by means of regime control and training on the middle and lower reaches;

- ❄ With the upstream reservoirs trapping sediment and regulating flow in low water seasons, thus improving navigation conditions in combination with river training.

- ❄ Canalizing tributaries and the upstream mainstream with the development of cascade projects to improve navigation condition and expand navigable mileage.

3.7 Ecological maintenance

● ❄ Water and soil conservation

The water and soil conservation in the Valley shall be in line of the principles that *prevention first, conjunction of prevention with rehabilitation, adaptation to local conditions, and comprehensive rehabilitation,* and shall be carried out according to the following:

(1) ❄ strictly enforcing the Forest Law, Land Administration Law, Water Law, and Water and Soil Conservation Law promulgated by the state;

(2) ❄ strengthening leadership and policy;

(3) ❄ in conjunction of rehabilitation with development and poverty-relief, implementing comprehensive rehabilitation with mini-basins as elements;

(4) ❄ securing the funds for water and soil conservation;

(5) ❄ setting up fully the water and soil conservation agencies at all levels, replenishing professionals and enhancing scientific research.

The highlights of soil erosion rehabilitation are:

(1) ❄ laborating land use planning, taking appropriate structural measures to rehabilitate sloping lands;

(2) ❄ finding ways to substituting for the conventional energy sources for domestic uses in rural areas, protecting vegetation and increasing vegetation coverage;

(3) ❄ trengthening supervision to prevent from emerging human-related soil loss;

(4) ❄ estoring the key areas suffering from water and soil loss in a stepwise manner. In the near term targeting at the downstream area of Jinshajiang River, the middle and lower Jialingjiang River Valley, Three Gorges reservoir area, Danjiangkou reservoir area and the upstream area of Hanjiang River;

(5) ❄ stablishing the forecasting and pre-warning system for debris flow and landslides to reduce damages.

• ❄ Water resource protection

The sewage discharges totaled about 25.6 billion m^3 in the Yangtze Valley in 1997. Based on the monitoring of 22,020 km long river courses in low water season, 9,530 km long river courses (43%) are of Grade I and II water quality, 8,020 km (37%) of Grade III water quality, 3,380km (15%) of Grade IV and V water quality and the rest 1,090km (5%) of higher Grade. From the perspective of pollution degree, Jinshajiang, downstream of Yangtze mainstream, the Yangtze delta, Taihu Lake and maritime waters are comparatively seriously polluted.

Water pollution control requires the integrated and coordinate planning for both the mainstream and tributaries, and the upstream and the downstream. The riparian water bodies in the cities along the Yangtze are focus of pollution control, and the sources withdrawn for drinking water should be emphatically protected. The harmonious development of both economy and environment must be emphasized, since the squandering of resources and energy as a result of aimless economic development gives rise to environmental pollution as one of the major factors. Therefore, it is essential to carry out the policy of *prevention first with conjunction of prevention and treatment*, rigorously control the polluting sources and the total pollutant load of water bodies in terms of their water quality targets which are set according to different zoning of water body functions. The rivers having been polluted should proceed to be restored soonest in a comprehensive way, and the basin-wide system of water resource protection, surveillance and law enforcement should be further perfected.

3.8 Hydropower development planning

Hydraulic resources is the most abundant energy source in the Yangtze Valley, comparatively the coal storage whereat is rather small. The upstream area in southwestern China is rich in hydropower potential with a certain amount of coal storage; the middle river valley in central China is limited in both exploitable hydropower potential and coal resources; whereas the downstream area in eastern China is devoid of all kinds of energy sources, but where the electricity demand is greater than in any other area.

The level of the Yangtze hydraulic resources exploitation remains low. Therefore, hydropower development needs to be strengthened paralleling the development of thermal electricity. Most of the hydropower projects on the Yangtze are characterized by multiple purposes, that is to say, power generation is well combined with among other things the regional flood control, navigation and irrigation, ecology and environment, thus comprehensive utilization benefits can be achieved.

The principles considered in hydropower development planning include:

- In line with the power demand and energy resources distribution of each region, hydropower shall be developed as much as possible specific to the region which is in urgent need of electricity but is in short of mineral energy resources, provided hydropower potential is available;

- In the light of load demand increase, priority of development should be given to those hydropower projects which have good regulation capacity, great comprehensive benefits, sound dam site condition, easy accessibility, adequate preparation, short distance from the load center, and relatively small inundation loss;

- To speed the construction of large scale power stations, with which as a backbone to integrate the middle and small scale projects;

- For the Western areas, the preparation work for hydropower development shall be strengthened so as to get ready for the future extensive development.

3.9 The Yangtze mainstream planning

The preponderance of harnessing and development tasks with respect to different reaches on

the mainstream varies with their respective characteristics and requirements that are not necessarily the same. For the reaches upstream of Yibin, the major tasks of development are power generation, navigation, industrial and agricultural water supply and sharing the responsibility for flood control in the middle and lower river valley. For the reach between Yibin and Yichang, the major tasks are defined as flood control for the middle and lower river valley, power generation, navigation and water supply. While for the reaches downstream of Yichang, the major tasks are flood control, navigation, industrial and agricultural water supply, river course training and riparian utilization. The outline of mainstream harnessing and development planning is defined as:

- On the upstream, to take advantage of the superior natural conditions of the canyon reaches to build multi-purpose controlling projects bidding for meeting the requirements for flood control, power generation and navigation.

- On the middle and lower reaches, to keep on heightening and stabilizing embankments and constructing the flood-diversion areas, to clear the obstacles impeding flood discharging in the river course and speed the river training.

The theoretical hydropower potential of the reach from Yushu to Shigu on the Jinshajiang River, the upstream of the Yangtze, is up to 13,000MW, power generation is thus the major task with regard to development of this section. It is preliminarily envisaged to develop 9 cascades, namely in the order from the upper to the lower Dongjiula(NPL 3,530m), Saila(NPL 3,440m), Ernan(NPL 3,360m), Baili(3,210m), Jiangqu(NPL 3,010m), Batang(NPL 2,720m), Wangdalong(EL 2,520m), Rimian(NPL 2,300m) and Tuoding(NPL 2,100M). Of the total storage capacity of 47 billion m^3, 13.57 billion m^3 of volume is for benefit promotion. The total installed capacity is 11,737MW, affirmed output 3,574MW and annual power output 63.1 billion kWh.

On the reach from Shigu to Yibin, there is plenty of flow with long term mean annual flow of 145.5 billion m^3 accounting for 1/3 of that measured at Yichang station. Besides, the big head fall also contributes to the rich water energy on this section, whose theoretical potential is 43,200MW, covering 46% of the mainstream theoretical hydropower potential. On both banks of the deep-gouged river are high mountains, being suitable for erecting high dam and large reservoir. The major tasks to tap this section include power generation, flood control, navigation and water and soil conservation. The proposed cascades to develop are Hutiaoxia(NPL 1,950m), Hongmenkou(NPL 1,600m), Zili(NPL 1,400m), Pichang(NPL1,280m), Guanyinyan (NPL 1,150m), Wudongde(NPL 950m), Baihetan(NPL 820m), Xiluodu(NPL 600m) and Xiangjiaba(NPL 385m). The completion of all the 9 cascades will give rise to a total storage capacity of 81.44 billion m^3, flood-control storage of 12.64 billion m^3, installed capacity of 50,330 MW, firm output of 24,790MW and an annual power production of 274.67 billion kWh.

The main development tasks of the reach from Yibin to Yichang are defined as flood control, power generation and navigation improvement. There are 5 cascades under planning namely Shipeng(NPL 265m), Zhuyangxi(NPL 230m), Xiaonanhai (NPL 195m), Three Gorges(NPL 175m) and Gezhouba(NPL 66m), of which the Gezhouba Project has been completed and the Three Gorges Project is under construction. The accomplishment of the 5 cascades will produce a total storage capacity of 54.25 billion m^3, flood control storage of 22.15 billion m^3, installed capacity of 25,425MW, firm output of 7,438MW and annual power yield of 127.5 billion kWh.

On the middle and lower mainstream reaches downstream of Yichang, the water surface gradient is 0.02‰. There are many large and middle size cities, mines and factories, engineering structures and important harbors distributed alongside the river on both banks where the terrain is flat. This area is of important significance for national economy. The main tasks of river harnessing involve flood control, navigation and riparian utilization oriented river course training.

3.10 The development tasks of major tributaries

On the basis of natural conditions of the river and local socio-economic characteristics, the

major tributaries of the Yangtze can be generally sorted into three types:

Type 1: Gorge-type rivers, such as Yalong, Daduhe, Wujiang, Qingjiang and Yuanshui, etc. Such river valleys are sparsely populated, with only niggard arable lands but vast water energy and natural resources. It is advisable to take advantage of the favorable geomorphic and geologic nature as well as the trait of little inundation loss to construct and controlling projects with high dams, improve the runoff regulation level, develop fully the water energy, raise the food control capacity of the downstream, and facilitate navigation. Some of the rivers, premising that the flood control tasks of their own basins are fulfilled, shall share responsibilities for flood control of the middle and lower Yangtze Valley to a proper extent.

Type 2: Rivers in hilly and plain areas, originating from high mountains and flowing through hilly and plain areas, such as Minjiang, Tuojiang, Jialingjiang, Hanjiang, Xiangjiang, Zishui and Ganjiang, etc. In this type of river basins, there are dense population and large quantities of farmlands with urgent need for irrigation, water supply, power and navigation. Controlling projects should be built on their middle and upper gorge-type reaches to regulate the runoff so as to meet the requirements for flood control and irrigation, water supply as well as to develop water energy and improve navigation conditions. Some tributaries, such as Hanjiang River, contribute a lot to the flood control of the Yangtze mainstem.

Type 3: The middle and small rivers in the middle and lower Yangtze Valley draining themselves into the Yangtze or lakes. They are similar in characteristics to those of the Type 2 rivers except for Huangpujiang River and a few other plain-type rivers but their development potential and effect are both rather smaller. The major tasks toward development thereof are flood control, waterlogging relief, irrigation and navigation.

4. Valley Management

4.1 Organizations

The water administrative management organization of the valley is constituted of four levels:

- ❄ The Ministry of Water Resources—the water administrative authorities of the State Council
- ❄ Valley agency(Changjiang Water Resources Commission)—an organization dispatched by the Ministry of Water Resources in Yangtze River Valley
- ❄ Provincial departments of water resource
- ❄ Local (county) departments of water resource

4.2 Structure

The system of unified management is adopted by the State for the water resource in conjunction with management by different levels and different sectors. The Ministry of Water Resources takes charge of overall management of the water resource of the whole country, while other departments of the State Council concerned, as the coordinators to the Ministry of Water Resources in this sector, are responsible for relevant water resource management in accordance with the division of responsibility by the State Council. Changjiang Water Resources Commission is a comprehensive agency exercising, representing the Ministry of Water Resources, the water administration in the Yangtze Valley. The local authorities of water administration and other departments concerned are responsible for related water resource management in accordance with the division of responsibility assigned by the same level government.

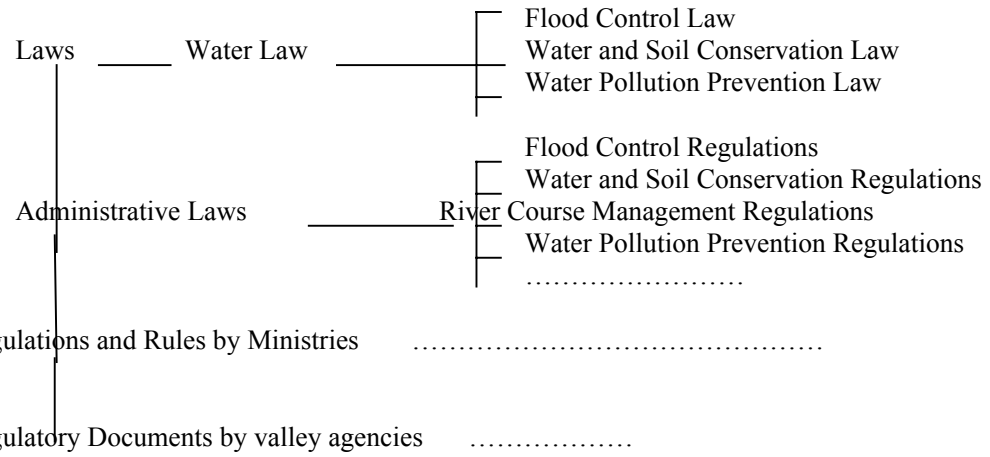
The main functions of Changjiang Water Resources Commission in the valley are: to publicize and implement the Water Law and relevant lines and policies; participate in the formulation of water management laws and regulations; be responsible for the investigation and study on water resource lines and policies; participate in system reform in water sector; coordinate and settle inter-province and inter-sector water-related disputes and contradictions in the Valley; be accountable for law enforcement in water sector in the Valley.

4.3 Legal and regulatory structure

The legal and regulatory structure of the valley management mainly includes two levels: state and local.

- The state legal system includes laws, statutes, administrative laws and ministry-formulated regulations and rules. The regulatory documents formulated by the valley agencies are subordinate to those by ministries and commissions. As to specific laws and regulations, see the chart attached below.

- Local legal system includes local regulations and rules and other regulatory documents.



4.4 Pricing system

So far, no complete water pricing system avails in the valley. As required by "Policies for Water Conservancy Industry" issued by the State Council, the Ministry of Water Resources and provincial governments are formulating the "Implementation Procedure of Policies for Water Conservancy Industry" and the "Implementation Program of Policies for Water Conservancy Industry", the performance of which will provide basis for the setup and collection of water price, electricity price and water resource fee.

General speaking, it is prominent that the existing water price, collection rate and utilization efficiency are very low.

5. The highlights and priorities of work for the future

The Yangtze is one of the mother rivers of China, having bred the ancient Chinese civilization. In the long historic process, the Yangtze Valley has made immortal contributions to the socio-economic development of China. In the next century, the Yangtze will continue to play a decisive role and hold a very important standing. So the protection, development and management of the Yangtze water resource deserve further strengthening.

5.1 strengthening the integrated water resource management in the Valley as well as the function played by the valley organization in integrated management

- ❄ Consolidating the legal status of the valley organization in the integrated water resource management of the Valley;

- ❄ Getting in order the relationship between river valley management and regional management;

- ❄ Investigating the relationship between integrated water resource management and decentralized management(in line of different sectors) on the basis of the multi-functional features of water resource.

5.2 Further strengthening the planning and management of water resource utilization in the valley and studying the economic policies and legislation promoting water resource protection and comprehensive utilization.

5.3 The Yangtze flood control undertakings in the future

- ❄ To sum up the experience and lessons obtained for years in Yangtze flood control practice, and revise the overall flood control planning for the Yangtze Valley according to the physical conditions and flood characteristics in the middle and lower Yangtze Valley, present flood control capability and the requirement of socio-economic development.

- ❄ The flood control countermeasures in the middle and lower Yangtze Valley after Three Gorges Project Operation

The operation of Three Gorges Project starting from 2009 will radically change the rigorous flood control situation of Jingjiang reach, however the flood control problem still persists and protrudes because of the unbalance between the inflow and the discharging capacity of the river courses in the middle and lower reaches, particularly downstream of Chenglingji. After the operation of Three Gorges Project, the flood regulation in the middle and lower Yangtze Valley shall still stick to the policy of " combination of storage and discharging with discharging as the predominant". Controlling projects on the mainstream and tributaries are to be constructed to improve the flood regulation and storage capacities of the upstream reservoirs; To continue stabilizing stem dikes, construct high level embankments, remove siltation and impediments, dredge river course to improve the flood discharging capacity; To remove embanked areas for flood discharging and restore farm land into the original lake in a planned manner, strengthen the rehabilitation and security measure of flood diversion areas, and improve their flood diversion capacities.

In conjunction with other development tasks, it is planned to construct a series of multipurpose projects on Jinshajiang River (upstream reach of the Yangtze) and major tributaries to enhance the flood regulation and storage capacity, so as to reduce the diversion flow downstream. The controlling projects which have large flood-control storage and the possibility to be developed in the near future are enumerated as Xiluodu and Xiangjiaba on Jinshajiang River, Zhipingpu on Minjiang River, Pubugou and Gongzui on Daduhe River, Tingzikou on Jialingjiang River, Goupitan on Wujiang River, Shuibuya on Qingjiang River, Danjiangkou (to be heightened) on Hanjiang River and Xiajiang on Ganjiang River.

To continue stabilizing the key levees on the middle and lower reaches according to the actual flood level occurred in 1954, including Jingjiang Levee, Wuhan City Levee, Wuwei Levee, Nanxian Levee, Hanjiang Levee and the dykes protecting such cities as Shanghai, Nanjing, Wuhu, Anqing, Jiujiang, Nanchang and Changsha. In the meantime of constructing dykes, to continue river training and revetment, river courses dredging and impediment removal so as to stabilize the bank.

To study further the relations in flood control between rivers and lakes, to stepwise implement the flood control works in Dongting Lake, Poyang Lake and Caohu Lake areas, and speed the construction of automatic systems for flood control forecast, decision-making and dispatching.

5.4 Speeding up the implementation of S-N Water Transfer Project

•❄ Planning of S-N Water Transfer Projects

The water resource, unevenly distributed in China, are affluent in the south and scarce in the north. The runoffs in the Yangtze Valley and the areas south of it cover 80% while the farmlands cover less than 40% both of the nation's totals. By contrast, the runoffs and farmland in the northern Huanghe, Huaihe and Haihe river basins cover 6.5% and 40% respectively of the nation' s totals. The water scarcity in Northwest China, North China and Henan and Shandong provinces has become the constraint of national economic development and eco-system improvement, necessitating trans-basin water transfer as a supplement. The 960 billion m^3 of mean annual runoff of the Yangtze is sufficient enough for water export.

Water transfers from the Yangtze take such routes as the West Route, the Middle Route and the East Route and an additional route feeding Huaihe River as planned, each having its respective water-supplying area. All the routes can co-exist and supplement one another. The West Route, of which the pre-preliminary planning has been finished, is planned to transfer water from Tongtianhe, Yalongjiang and Daduhe Rivers, the upstream reaches of the Yangtze, northward to the upstream of Huanghe (Yellow) River, to solve the water-shortage problem of Northwest area. The Middle Route, with feasibility study done, is planned to supply water diverted from Danjiangkou Reservoir to the western part of the plains of Huanghe, Huaihe and Haihe river basins for industrial and urban domestic use, especially for the domestic use of Beijing and Tianjin municipalities. The East Route, with planning completed, is to pump water from the downstream Yangtze all the way to the north along the ancient Beijing-Hangzhou Grand Canal, supplying water for the eastern part of the plains of Huanghe, Huaihe and Haihe river basins. The Huaihe River feeding scheme is planned to pump water at Fenghuangjing or divert by gravitation at Yuxikou Sluice from the Yangtze, via Caohu Lake and traversing the divides, to feed Huaihe River for agricultural and urban domestic water uses as well as for navigation facilitation.

•❄ Researches on the Middle Route Project (MRP) of S-N Water Transfers

The Middle Route Project of S-N Water Transfers has seen the accomplishment of its feasibility study, which is briefed hereinafter.

(1)❄bjective and scope of water supply of MRP

The main objectives of MRP are to supply water to Beijing, Tianjin and North China for urban domestic and industrial uses as well as, if possible, for agricultural and other uses. The water supply scope includes the territories of Beijing Municipality, Tianjin Municipality, Hebei Province, Henan Province and Hubei Province.

(2)❄eeds for MRP

The contradiction between water shortage and socio-economic development and environment protection has long been prominent, necessitating trans-basin water transfers to ease the problem in the water-stress areas. The MRP is planned to divert water, in the short term, from Danjiangkou Reservoir with the advantages of premium water quality, flowing by gravity both northwardly and eastwardly, reliable flow and superior geographical conditions. The lunching of MRP will ease the severe water stress of the water-importing area and promote its social, economic and ecological development in harmony with the environment.

(3)❄anjiangkou Reservoir and transferable water quantity

Danjiangkou multipurpose water resource project, located in the city of Danjiangkou in Hubei Province, is a controlling project as a component of the flood control system in the middle and lower Hanjiang river valley and acts as a backbone power station of Central China Power Grid, having as well other comprehensive benefits including irrigation, navigation and aquiculture.

The initial stage of this project was completed in 1973 with NPL 157m and corresponding storage 17.5 billion m^3. The final stage project will raise the NPL to 170m and increase the flood control capacity from the initial 7.67 billion m^3 to 11 billion m^3, thus essentially eliminating the flood control problem in the middle and lower reaches by means of supplementary scheduling of the reservoir in case the flood equivalent to the year 1935 event (about 100-year frequency) in magnitude recurs. As for Danjiangkou power station, there are six units installed with total capacity of 900MW and firm output of 236MW and annual power production of 3.38 billion kWh.

The regulating capacity of the reservoir after heightening of the Danjiangkou Dam will be increased, making it possible to transfer 14.5 billion m^3 of water per annum under the premise that various water use requirements of the downstream are met. As the water source project of MRP, the reservoir therefor has tremendous comprehensive utilization benefits.

(4) The alignment of the MRP canal

The trunk canal is aligned according to the principle of flowing by gravity. Starting from Taocha headworks, it proceeds northeastwardly traversing the hill-plain alternating terrain on the south pediment of Mt. Funiu, then crosses Baihe River to the north of Nanyang City and enters into Huaihe River Basin through Fangcheng, a topographical saddle on the dividing ridge. Further north, it crosses the Huanghe River at the location west of Zhengzhou, then runs paralleling the Beijing-Guangzhou Railway, and finally terminates at the Yuyuantan Pool in Beijing. Of the 1246km long canal, 708 km runs in Henan Province, 462 km in Hebei Province, 76km in Beijing Municipality. In addition, there is a bifurcated branch leading to Tianjin with a length of 114km.

(5) Investment and construction period

The MRP consists of the final stage of Danjiangkou Project, resettlement and dealing with inundation, local supplementary projects in the middle and lower valley of Hanjiang River, trunk canal (including Tianjin Branch and Huanghe crossing) and environment protection projects, excluding the auxiliary structures in water receiving areas. Based on the year 1995 price level, the total static investment corresponds to 51.8 billion CNY.

The construction period is preliminarily set to be 6 years.